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PLANT COMMUNITIES OF THE SERRA DOS CARAJÁS (PARÁ), BRAZIL[1]

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ABSTRACT - *The Serra dos Carajás, or Carajás Mountain Range, is located in the south of the state of Pará, Brazil, in the municipality of Parauapebas (5°54' - 6°33' S and 49°53' - 50°34' WG). This region has several mineral deposits, among which are large deposits of iron ore. The iron ore is covered by a layer of hematite concretion which represents a stage in the weathering of the underlying iron. On this soil, locally called "canga", there grows a type of savana vegetation with particular phytosociological and floristic characterisics. A study was done of this vegetation for the purpose of describing and classifying the vegetation in general terms; integrating knowledge of compositional and spatial plant distribution with mineralogical-geological studies of the Quaternary and with limnological studies. Phytosociological surveys followed, basically, according to the Zürich-Montpellier school. Vegetation types were recognized as either non-zonal (lakes, swamps, savannas, and savanna forests) or zonal (Amazon forest). The identified plant communities were the following: Amazon forest, dry savannas, and savanna lakes and ponds. Surveys were made of the latter two types of vegetation, and the vegetation grouped in natural communities. An attempt was made to separate the lotic vegetation as meso-eutrophic or meso-oligotrophic.*

KEY WORDS: Amazonas, Brazil, Carajás, Savanna vegetation, "Canga hematitica" vegetation, Plant ecology.

RESUMO - *A Serra dos Carajás localiza-se no sul do estado do Pará (Brasil), no município de Parauapebas, entre5°54' - 6°33' S e 49°53' - 50°34' WG. Possui uma série de jazidas minerais, entre estas, grandes depósitos de ferro. O corpo de minério de ferro é recoberto por uma camada de canga hematítica que*

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representa um grau de intemperização do minério. Sobre a camada de canga cresce um tipo de vegetação savanoide com características fisionômicas e florísticas bem peculiares. Foi realizado um estudo daquele tipo de vegetação com o objetivo de descrever e classificar a vegetação em termos gerais, a fim de integrar os conhecimentos obtidos em termos de composição e distribuição espacial aos estudos limnológicos e mineralógicos-geológico do Quaternário. Parte dos levantamentos fitossociológicos seguiu, basicamente, a escola de Zurich-Montpellier. Foram distribuídos arbitrariamente: vegetação azonal (lagos, claros, savanas e bosque de savanas) e vegetação zonal (floresta amazônica). As comunidades vegetais identificadas foram as seguintes: floresta amazônica; savana seca, lagos e lagoas savaneiras. Nos dois últimos tipos foram efetuados levantamentos, e a vegetação agrupada em associações. Nos lagos e lagoas pequenas foi analisada a vegetação quanto a seqüência hidro-higroséries. Houve uma tentativa de agrupar a vegetação dos lagos estudados quanto ao sistema trófico em meso-eutrófico e meso-oligotróficos.

PALAVRAS-CHAVE: Amazonas, Brasil, Análise de vegetação, Ecologia vegetal, Carajás, Vegetação de "canga hematítica".

INTRODUCTION

A multidisciplinary Brazilian-French expedition was carried out in the savanna-covered mountains of Carajás, surrounded by Amazon rain forest in the State of Pará, Brasil. The study area of the Serra dos Carajás (5°54' - 6°33' S and 49°53' - 50°34' WG) is about 750 km S of the Amazon delta and enclosed by the rivers Araguaia and Itacaiúnas. A study is part of a larger research whose objectives are to study Quaternary climatic alteration and to model these changes for future studies of climatic change in the Amazon. A survey was done of this vegetation for the purpose of describing and classifying the vegetation in general terms; integrating knowledge of compositional and spatial plant distribution with mineralogical-geological studies of the Quaternary and with limnological studies.The main aim was to collect sections of lake-sediments, and simultaneously, to carry out studies on limnology and vegetation. The present contribution deals with the plant communities of the savanna and the lakes, including open water and hydroseral swamps. Partial results of the research are presented here.

METHODS AND MATERIALS

Detailed information on the locality and characteristics of this study are given by Silva *et al.* (1988). The climate data are: annual precipitation in the Serra Norte and surroundings varies between 1400 and about 3150 mm, and mean temperature between 26.2 (lowland 203 m alt.) and 23.5 degrees Celsius (uplands 835 m alt.).

Field work for this study was undertaken in the Serra Sul and Serra Norte uplifts, Carajás (Figura 1 a, b).

In modern plant communities of the Serra Norte, and especially the Serra Sul of Carajás, we studied the vegetation of open savanna (campo rupestre), savanna scrub and savanna forest, as well as lakes with open water and hydroseral swamps. The terminology 'savana' refers to the open vegetation called 'savana metalofila' (Porto & Silva, 1989). The surrounding rain forest was previously studied by Silva *et al.* (1986a, b, 1988).

The field survey in the Serra Sul was carried out by helicopter of the Carajás mining company, which also supplied transport by car to Serra Norte (Lagoa Verde and surroundings). The same company also provided laboratory and housing facilities at the DOCEGEO camp. Relevés of the vegetation were taken according to the Zürich-Montpellier method with minor adaptions (Cleef 1981). Coverage values of species were estimated and based on contour projection. Botanical collections (under the reference number of the relevés Cleef & Silva 853-921) and vouchers were sent to the herbaria of Belém (MG) and Utrecht (U). For complete species names and their authors we refer to previous studies by Silva *et al* (1986 a, b and1988).

Vegetational analysis of the forest given here refers to the data of Silva *et al* (1988).

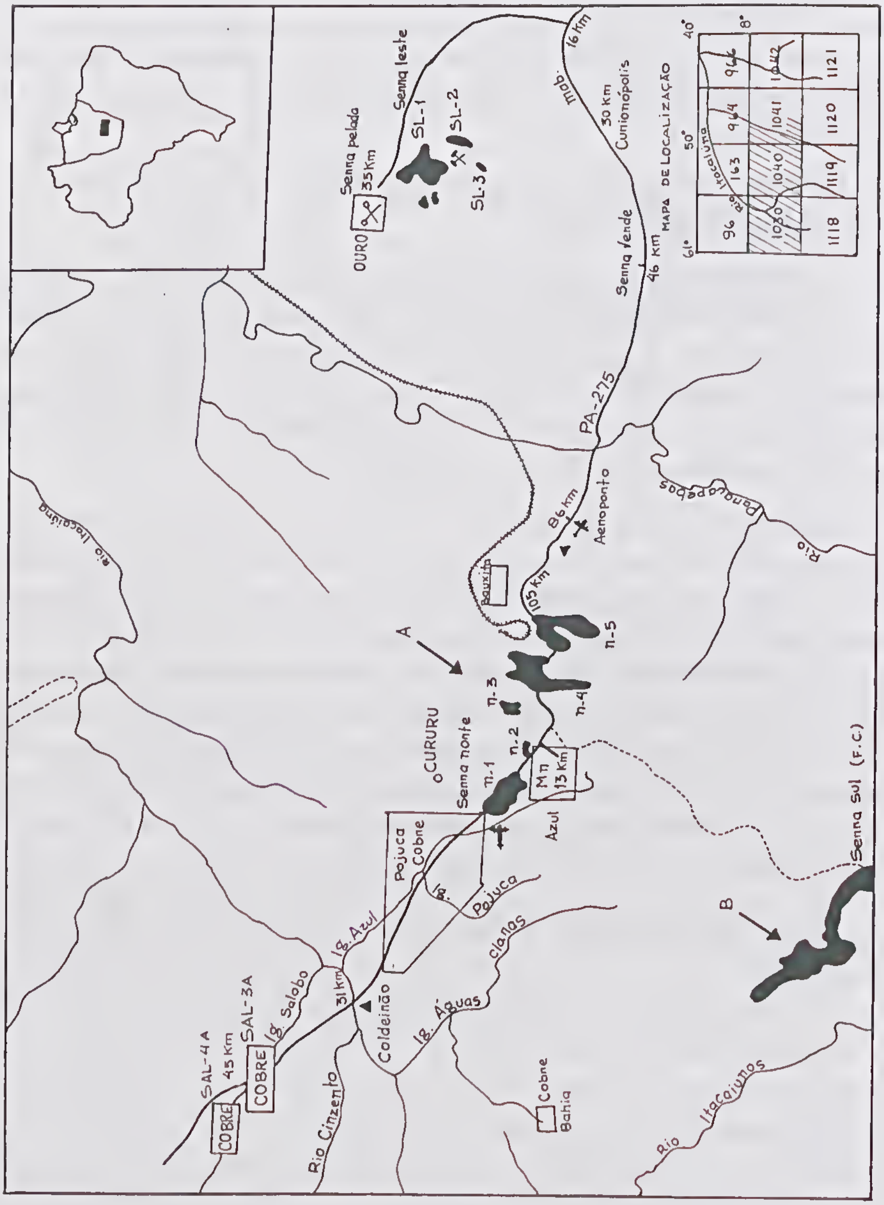

Figura 1. Localization Map of the Carajás Moutain Range

RESULTS

The principal types of plants communities identified in this study are:

1. Zonal Rain Forest (1)

The rain forest is in fact the zonal vegetation covering the larger part of the Carajás study area, and it is quite different from that of the western, more humid, part of Amazonas (Silva *et al.* 1986a, b; Duivenvoorden *et al.* 1988). It is one of the driest rain forest types of the Amazon basin, although the effect of the frequent upland mist reduces evapotranspiration. Dryness may be evidenced by (1) a well developed litter layer; (2) the presence of a number of deciduous trees, especially as emergents near surrounding outcrops, where soils, become thin; (3) the presence of coriaceous leaves; (4) relatively few vascular epiphytic species in contrast with quite a number of foliaceous and crustaceous epiphytic lichens; (5) low proportion of bryophytes and few hygrophytic hepaticae. A detailed account of regional differences in structure and floristics of Carajás rain forests has been published by Silva *et al.* (1986a, b). According to the family ecological importance value (Mori *et al.* 1983), Silva (1988) refers to respectively: Leguminosae, Sapotaceae, Vochysiaceae, Lauraceae, Meliaceae, Melastomataceae, Nyctaginaceae, Euphorbiaceae, Myrtaceae, Lecythidaceae. The number of species recorded was between 122 and 130 in 1 ha of rain forest of the Carajás. Species in the genera *Erisma*, *Neea*, *Aparisthmium*, and *Poecilanthe* are very common and abundant here.

2. Campo Rupestre (communities 2-7)

The dry campo rupestre vegetation (canga hematitica vegetation) covers the low mountains of Carajás, and may be considered as azonal terrestrial vegetation. Some six vegetation types can be distinguished, and their physiographic position are indicated with their reference numbers (2-7) in Figura 2. The two most common types are:

(2) Open treelet-scrub savanna with *Byrsonima coriacea-Croton* spp. (*C. agrophyllus - C. jatropha*) Gramineae (rel. C&F 856-886), which is characteristic of more or less open slope vegetation (8-12° inclination). Height of the vegetation is up to about 3 m. Rocky surface is conspicuous. Is present, too, *Sapium marginatum, Trachypogon sp.* and *Vernonia muricata. Boreria* cf. *latifolia* may be present with increased cover.

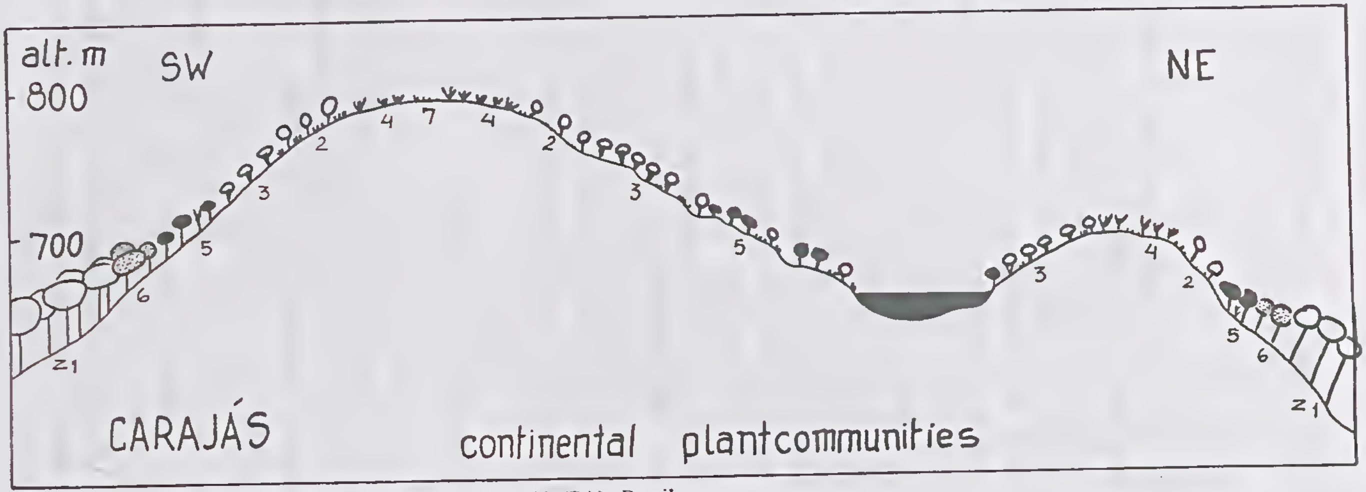

Figura 2 - Modern Plant Communities of the Serra dos Carajás (PA) - Brasil.

(3) Dense treelet-scrub savanna with *Mimosa acutistipula* var. *ferrea* and *Sobralia liliastrum* (rel. C&F 863, 881, 892, 915), which is characteristic of dry slopes (up to 20° inclination) with very thin layer of topsoil. Height of this vegetation is up to 4-6 m and there are more species in comparison to the previous type (64 versus 37). Diagnostic is the presence of *Mimosa acutistipula* var *ferrea*, in combination with *Lippia grandis, Neea* sp., *Anemopaegma* cf. *scabriuscula, Erythroxylon* cf. *citrifolium* sp. and *Phtirusa paniculata.*

More limited in extension are:

(4) Open to dense apical rosette savanna of *Vellozia glochidea* (rel C&F 861, 862, 905, 917, 923), which dominates on level areas of rocky watersheds. The branched *Vellozia* apical rosettes, up to 1.5 m, grow together with bromeliaceous basal rosettes of *Dyckia duckei.* Diagnostic is the combined presence of *Tibouchina aspera, Cereus* sp., *Ipomoea carajasensis, I. marabaensis, Classytha americana, Norantea goyasensis, Perama carajensis* and *Anthurium solitarium*; the latter three species are mainly shared with savanna type (2).

(5) Low savanna forest of *Callisthene minor* (rel C&F 864-870-918) grows in pockets, where water supply is sufficient and soil is less shallow than in the surrounding dry savannas. The pinnate-leaved vochysiaceous trees with stems covered by crustose lichens, attain only a height of 3-5 up to 12 m. On the forest floor a litter layer is well developed. Diagnostic is the dominancy of *Callisthene minor*, associated with *Pouteria ramiflora*, and in the scruby and herbaceous layers of the understory are present *Eugenia flavescens, Turnera glaziovii, Sobralia liliastrum, Ouratea castaneaefolia, Lippia grandis, Pilocarpus microphyllus, Mimosa acutistipula* var. *ferrea* and species of *Memora* and *Cereus.* Quite a number of bryophytes are present on decaying wood and on the forest floor.

(6) Treelet-scrub outcrop vegetation with *Cochlospermum orinocense, Myrcia* spp. and *Begonia guianensis* (rel. C&F 857). This is apparently the most common vegetation type of semi-open patches in zonal rain forest, where soils are shallow or almost absent. Were recorded, too, *Bombax* cf. *globosum, Alchornea schomburgkii, Eugenia flavescens, Guatteria poeppigiana, Peperomia vaupensis, Cuphea annulata, Abrus fruticolosus, Diclea crenata, Ananas ananasoides* e *Epidendrum purpurascens.*

(7) Level rock surfaces with *Paspalum carinatum, Trachypogon* sp. and *Ipomoea carajasensis* (rel. C&F 880-919). Here water collects after torrential rain for just a short time.

3. Savanna Lakes and Hydroseral Vegetation (communities 8-24 and 2)

In the Serra Sul are about 20 lakes, which, according to differences in depth and trophic conditions, contain open water and different stages of swamp vegetation (Figura 3). At the sampling time (3-4 months after the beginning of dry season) lake levels were about 1 m lower than in the wet season. *Mayaca* cf. *flaviabilis* was recorded in almost all relevés of open water and wet swamps.

(8) Open water with *Utricularia* cf. *obtusa* and *Cabomba aquatic*. Species-poor community dominated by ceratophyllids in open water up to 3 m depth. Only recorded in the Lagoa Verde and lake 9 (rel C&F 858, 912). In deep water of lake 1 the only aquatic growth are floating stems of *Cabomba aquatic* and *Mayaca faviabilis.*

(9) Open water with *Nymphaea rudgeana* and *Echinodorus tenellus* (rel. C&F 871 through 877). Aquatic community of up to five diagnostic species in 0.5-1 m deep water with pH values of about 5. Only observed in lake 9.

(10) Swamp with *Echinodorus tenellus* and *Limnanthemum humboldtianum* (rel. C&F 865, 889, 889A). Nymphaeid community associated with cyperaceous helophytes (*Eleocharis interstineta, E. fistulosa, Rhynchospora globosa*) near the shore of lake 9.

(11) Swamp with *Eleocharis interstineta* and *Rhynchospora holoschoenoides* (rel. C&F. 891, 866, 898, 903). Species-poor cyperaceous helophyte vegetation dominating in wet swamps of lake 8 and 9. Phreatic level between 10 and 50 cm.

(12) Swamp with *Rhynchospora holoschoenoides* and *Sagittaria* (rel. C&F 858, 860, 910, 911). Lax cushions of *Eriocaulon sellowianum* var. *longifolium* are also diagnostic, and were only observed in Lagoa Verde on top of 1-1.5 m thick sediments. Water table at surface in type (13) to (17).

(13) Open swamp forest with *Callophyllum brasiliensis* and *Limnanthenum humboldtianum* (rel. C&F 883). Observed along the muddy shore (pH 4.9) of lake 11. Treelets up to 4 m loaden with *Tillandsia* epiphytes. A dense stand with trees (15-20 m), but curiously almost all dead, was present on the opposite shore of lake 10.

(14) Herbaceous swamps with *Eleocharis fistulosa* and *Panicum parvifolium* (rel. C&F 895, 895A, 897, 902, 904, 913). Swamp type limited in extent, transitional between types (11) and (15); or (15) and (16). Common in lake 8, but also present in the Lagoa Verde.

(15) Tall cyperaceous swamp with *Xyris laxifolia* and *Rhynchospora corymbosa* (rel. C&F 878A, 894, 900, 901). Cyperaceous reedswamp up to 1 m, with *Ludwigia* cf. *mexiala* and *Tococa* cf. dwarfshrubs (2 m), scattered *Styrax pallidus* treelets (up to 4 m) and low caespitose *Panicum parvifolium*. Common in lake 8.

(16) Fern swamp of *Blechnum serrulatum* with *Schizaea* sp. Diagnostic also are *Ludwigia* sp., *Scleria foliosa* and *Panicum parvifolium* (rel. C&F 888). Present in lake 8, 10 and 19, where drainage of the swamp is seasonal and difficult.

(17) Fern-palm swamp of *Blechnum serrulatum* with *Mauritia flexuosa* (rel. C&F 882, 890). Locally along shores in matrix of types (18), this type probably marks the end of the succession on organic sediments in lake basins. Present in lake 8, 10 and 19.

(18) Dense graminoid swamp with *Panicum parvifolium* and *Abrus fruticulosus* (rel. C&F 878, 893). *Ludwigia* cf. *mexial* is also diagnostic. Is present in small zones transitional to shores in lake 8 and 9.

(19) Low cyperaceous mats dominated by a dwarfed of *Eleocharis filiculmis* (rel. C&F 877A, 879, 891A), on humid mineral soil in seasonal ponds and locally along shores of the lake 8, 9 and the Lagoa Verde.

(20) Herbaceous rosette vegetation dominated by slender rosettes (up to 1 m) of *Syngonanthus caulescens* var. *angustifolius* on rocky shores (rel. C&F 868, 885, 908, 909, 914). At the sampling time the rosettes were found completely dried along the dry shores of the Lagoa Verde and the lake 9 and 19.

(21) Dense tall graminoid shore vegetation dominated by *Ichnanthus tenuis* (with a bluish hue) only found in a small belt surrounding the Lagoa Verde (rel. C&F 914A).

(22) Dense Mimosoidea dwarshrub of *Chamaecriste* with *Mimosa* (rel. C&F 869, 884, 887). On rocky ground along shores of lake 9 and 19. Type (20) and (21) are locally transitional to scrub of *Ichthyothere terminales* (22a), which constitutes the end of shore succession of Carajás savanna lakes.

(23) Seasonally flooded low herbaceus savanna on level gravelly ground (shallow lakes) with *Xyris longiceps, Rhynchospora tenuis* ssp. *riparia* and *Riencourtia glomerata* (rel. C&F 853, 854, 855, 906, 907, 916, 921). The presence of *Utricularia nervosa, Burmannia* sp., *Syngonanthus gracilis* and *Borreria tenera* is diagnostic too. Only in the Serra Norte extensions of this savanna type, completely dry at the time of sampling, have been found in shallow lakes in contact with the Lagoa Verde. Small patches are locally present on flat watershed areas E of lake 8 in the Serra Sul (rel. C&F 921).

DISCUSSION AND CONCLUSION

Preliminary to a more detailed study of the savanna vegetation of the Serra Norte and Serra Sul of Carajás the physiographic position of the *dry terrestre vegetation types* are shown in an ideal transection (Figura 3). The types with the largest extense are the dry shrubby savannas with *Byrsonima coriacea* and *Mimosa acutistipula* var. *ferrea*, respectively. Savanna with *Byrsonima* seems proper to open rocky hill sides, while denser *Mimosa acutistipula* var. *ferrea* vegetation occurs on slopes with slightly deeper soil. *Callisthene minor* dwarf forest is present mainly in small-sized pockets on thin soils, and is locally transitional to zonal Amazon rain forest. The interesting *Vellozia glochidea* branched apical rosette communities covers mainly bare, rocky watersheds, the driest and perhaps most extreme habitat under Amazonian conditions. Seasonally flooded areas occur on more or less level areas on watersheds or in valley bottoms where, after torrential rains, water collects. An open graminoid savanna with Cyperaceae, *Ipomoea* and *Borreria* developed here.

The main sequences of *wet to humid vegetation types* are schematically presented in Figuras 3a,d. Have about troice more aquatic or wet communities in comparison with the dry terrestric communities, were recognized under different drainage and trophic conditions. Also different types of organic substrates were included.

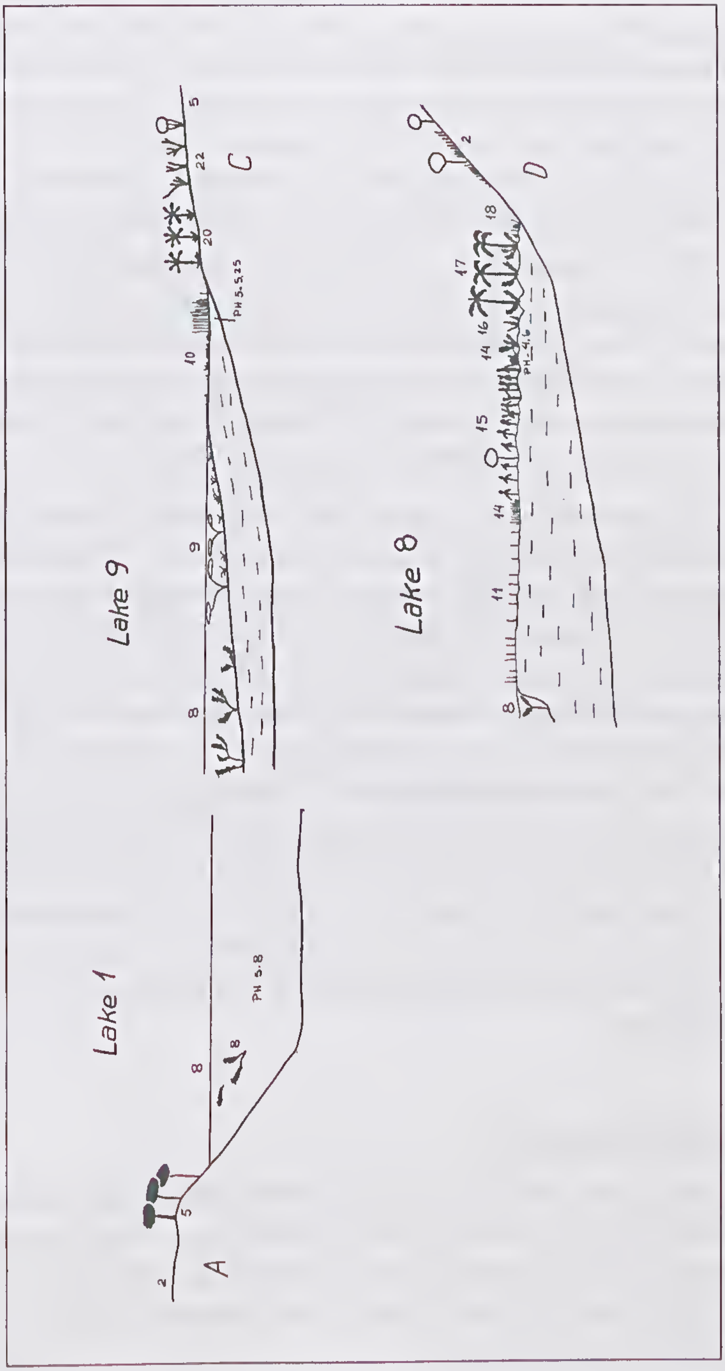

Figura 3 - Idem

Presently, lakes with open water or filled up with different stages of hydroseral swamp types are found. Open water in lake 1, 9 and 10 with pH values between 5.0 and 5.8 and strong wave action contains scanty plant growth (types 8-9). Other lakes (e.g. lakes 8, 9, 12, 19 and the Lagoa Verde) are more or less filled in with open, aquatic and swamps (with similar pH values as open water), apparently early in succession (types 10-14), and drier cyperaceous, fernbrake and palm swamps (types 15-17), which are most acid (pH values 3.6 to about 4.5) but relatively rich in nutrients (CEC 800 to about 900), and probably mark the end of hydroseral succession in lacustric waterbodies. On almost bare rocky ground amphibious shore communities developed. Of special interest is the *Syngonanthus caulescens* rosette vegetation, which completely dies back in the dry season, probably only persisting as seed.

Careful paleoecological analysis (Absy & Van der Hammen 1989) reveal changes of vegetation and climate in the past 50,000 years B.P. at least in the Carajás area with detailed information on the changing regional extent of zonal rain forest versus azonal savanna, but also on the local hydroseral sequences in lake waterbodies. It will be very interesting to correlate this paleo-ecological evidence with that of other areas of Amazonas. The present-day vegetation of the Carajás savana and lakes may be better understood when compared to refugial areas in the Cerrado of Central Brazil (Eiten 1972) and the trans-amazonian savannas of the northern Guyana shield in Surinam (Van Donselaar 1965), Venezuela (Huber *et al.* 1984) and in Colombia (Schultes 1944), as well as elsewhere in Amazonian. A phytogeographical analysis of the Carajás savanna flora in this context will contribute toward, a better understanding of the history and the present-day composition of the Carajás savanna ecosystems.

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